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Report of Professor W. G. Adams, on Observations of the Eclipse of December 22nd, 1870, made at Augusta, in Sicily.

King's College, London, February, 1871.

Before the final arrangements were made by the Organising Committee I was asked to join the English Eclipse Expedition. Not being able to leave with the other Members of either Expedition, on account of my lectures at King's College, I followed the Sicilian party on the evening of Friday, the 9th of December, and joined them on the morning of Wednesday, the 14th, in Naples. The *Psyche* arrived during the day, and we went on board, and she steamed out of harbour at four o'clock. It was a peaceful afternoon, with no wind and a perfectly calm sea, and the view of the bay, with Naples in the sunshine and Vesuvius sending out light puffs of steam and smoke, was very beautiful. The sea kept perfectly calm through the night, and on the morning of the 15th, after passing Messina, a meeting was held and observers were stationed. The instruments were brought on deck, and we were enjoying the scenery of the coast and of Etna when the unfortunate wreck of the *Psyche* cast a gloom over our Expedition and entirely altered our arrangements. It was intended that Syracuse should be the head-quarters, but now Mr. Lockyer took up his station at Catania. Professor Roscoe took charge of a party to observe on the slopes of Etna, and I was asked to take charge of the Augusta Expedition. The other observers for Augusta were—

Mr. Brett, with a reflector for sketching the corona;
Mr. Burton, with a spectroscope;
Mr. Clifford }
Mr. Ranyard } for observations on polarization;
Mr. Samuelson, for general observations.

Colonel Porter also volunteered to sketch the corona, and some officers of the Royal Engineers were expected from Malta for the day of the eclipse.

Mr. Brett was asked to proceed at once to Augusta and arrange with Colonel Porter about our camp and observatory.

With such an excellent practising ground as the terraces and gardens of the Benedictine Monastery, it was thought better that the Etna and Augusta observers should stay at Catania until Monday, the 19th, and practise with their instruments. As there had been no opportunity for testing the instruments, this comparison was very important, especially for all those who were to observe for polarization; some of whom had never seen their instruments. All the observers for polarization except Mr. Ranyard remained, and arranged the sets of observations to be made by each observer, so that if the weather was favourable, the determination of the polarization of the corona should be complete. We found this previous practice of very great value, and before we parted Mr. Griffiths and I made comparative observations with our polarimeters with very satisfactory results. Turning to

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the same points of clouds and buildings, we determined the plane of polarization, and measured the degree of polarization in the light at the rate of from 10 to 15 seconds for each point of observation; and in some cases our readings both for plane and degree of polarization were absolutely identical.

Description of Instruments.

To my own telescope ($2\frac{1}{4}$-inch object-glass), an altitude and azimuth instrument, I had fitted at the principal focus of the erecting eye-piece a plate of right-handed and left-handed quartz, a small Nicol's prism being placed at the stop. I had also requested Mr. Ladd to fit to my telescope a polarimeter eye-piece, consisting of a Savart's polariscope (a plate of quartz cut obliquely, and a Nicol's prism), with four plates of glass for a depolariser. Just before I left for Sicily, Professor Stokes expressed a wish that I would use the double-rotating quartz to test the observations made by Prazmowski at the Eclipse of 1860, and recommended that Mr. Ranyard and I should observe at different places along the central line. Accordingly, it was arranged with Mr. Ranyard at Catania, that on the morning of the 22nd he and another of our party should drive some miles up from Augusta, in the direction of the hills of Carlentini to observe the eclipse.

On comparing my two eye-pieces, I found that when the polarization was not strong, the double-rotating quartz eye-piece was not nearly so delicate as the polarimeter eye-piece for detecting the plane of polarization, but gave a clearer view of the point of observation. In addition to these, Mr. Becker had fitted up for me another polarimeter to be used without a telescope, consisting of four glass plates, a very delicate natural quartz crystal, giving right-handed and left-handed rotation, and a Nicol's prism. When the planes of polarization of the polariser and analyser are coincident, the crystal gives a central white band with a tinge of red on the outside of it; then a dark purple band, gradually shading outward through blue, green, and yellow, to the pink field covering the remainder of the crystal. On turning the analyser the bands move parallel to themselves across the field, each colour occupying the position of its complementary colour, when the analyser has been turned through a right-angle, the tint on the outside of the field being a bluish green. The crystal was placed behind the glass plates and the Nicol's prism at the other end of a telescopic tube. By drawing out the tube to about one foot in length the field of view could be reduced to about six diameters of the Moon. This tube was supported and could turn in another tube which was attached to a wooden stand which allowed of motion in altitude and azimuth. By position circles on the fixed tube and on the box containing the glass plates, the plane and degree of polarization could respectively be determined. The existence of the dark bands in this crystal made it so delicate that, with faint light

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when there was not a trace of colour to be seen, I could detect polarization and approximately determine the plane, and on a dark day I could determine the plane and the degree of polarization on the clouds when there was not more than one per cent of polarization. With this instrument I had intended to make observations on the sky before the eclipse, and during totality to observe the streamers and the body of the Moon if time permitted, in addition to making two or three observations on the Corona with the Prazmowski arrangement. I had hoped to have an officer of the Royal Engineers to assist me and confirm my observations, and should have taught him how to use the instrument for the observations during totality. I had intended to register the observations by drawing lines against the index as a ruler with a pencil of a different colour for each observation, writing the number of the observation with the same pencil. I also took out with me an extra telescope, the eye-piece being fitted with a plate made up of two wedges of quartz with their axes at right-angles to one another and to the axis of the tube. Mr. Pierce, jun., of the American party, was at Catania, and as his spectroscope had not arrived, the eye-piece of this telescope was lent to him to fit to his own small telescope, Mr. Ranyard having taken its proper tube and object-glass to Augusta.

On Monday, the 19th, Mr. Clifford and I left Catania in a boat to go to Augusta. In consequence of a breeze from the sea we did not reach Capo San Croce until eight o'clock, and after turning it we had a strong land breeze against us from the west. Twice during the evening, about half-past six and again about seven o'clock, we saw a brilliant display of the aurora. It was far more brilliant than the remarkable aurora which I had seen in October, and more beautiful than any I had ever seen. First, pink streamers shot up perpendicularly to the eastern horizon, passing across the planet *Jupiter.* I judged that these must have been in or very near to the ecliptic. These were followed by other streamers shooting up from the north and north-east until the sky became covered with a pinkish mauve colour. Round the eastern and northern horizon there was a faint hazy grey light as if a thick mist were coming on, but which was seen to be connected with the aurora by its fitfulness. The zodiacal light was seen in the western sky near the ecliptic as a hazy white light. As the evening grew darker we saw the strong phosphorescence of the sea. There was a bright glow on the drops thrown up by the oar as it struck the water, and the forms of the eddies caused by the bending of the oar were distinct and brilliantly illuminated.

Through the kindness of Prof. Cavalieri Cacciatore of the Palermo Observatory, and Father Denza, who made comparisons for time, I was able to obtain the latitude and longitude, as well as the local times of the different phases of the eclipse according to their calculations.

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Latitude of Fort Augusta	.. ..	37° 14′ 0″·6 N.
Longitude (in time)	.. ..	$1^{h}\ 0^{m}\ 52^{s}{\cdot}2$ E.
Difference of longitude between Augusta and Palermo	.. ..	$7^{m}\ 26^{s}{\cdot}6$

Local Times.

		Italian. h m s	Hind. h m s
First contact ..	..	0 39 17	
Beginning of totality	..	2 1 56·7	2 1 51·8
Middle.. ..	..	2 2 52·1	2 2 46
End of totality ..	..	2 3 47·5	2 3 40·3
End of eclipse ..	..	3 21 21	
Duration of totality	..	1 50·8	1 48·5

The following observations were made with my Aneroid Barometer registering from 31 inches to 15 inches, and which had been regularly compared with a standard barometer, and found to indicate pressures very accurately.

Day.	Hour.	Pressure.	Remarks.
Dec. 20	9 A.M.	29·87	
	12 NOON	29·82	
	3 P.M.	29·82	
	6 P.M.	29·77	
21	7 A.M.	29·68	
	12 NOON	29·65	
	8 P.M.	29·50	Report of bad weather in Italy and Sicily; wind westerly; sirocco expected.
	11 P.M.	29·45	
22	7 A.M.	29·28	Dec. 22, 2 A.M. Sirocco from the west; very heavy rain; frequent thunder and lightning. 6 A.M. No rain; little wind; lightning in eastern horizon and in heavy stratus cloud to the south-east. 7 A.M. Rain and heavy clouds. 7 15 A.M. Wind rising and becoming violent; clouds in patches.
	11 45 A.M.	29·37	
	12 10 P.M.	29·32	Sky of a watery light blue.
	12 40 P.M.	29·28	Time of first contact.
	3 P.M.	29·30	
	4 40 P.M.	29·30	Wind again becoming violent.
	6 P.M.	29·35	Very high wind.
23	8 30 A.M.	29·44	Bright morning, followed by a fine day.

My barometer was compared with Mr. Burton's smaller aneroid, which showed greater variations than mine, but generally in the same direction.

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The five divisons of our observatory were occupied in order by:—

(1) Mr. Brett.
(2) Mr. Burton.
(3) Colonel Porter.
(4) Mr. Clifford.
(5) Myself.

Each observer had one of the Sappers to assist him in preparing his instruments and in recording any notes which it might be necessary to make during totality. Where they were required, tables formed by driving piles into the ground and nailing planks on them were erected for our telescopes.

On the 21st we were able to get our instruments into position, and the Sappers showed their skill in repairing parts of instruments which were out of order.

On the 21st, at 2 P.M., the hour of totality, I fixed my telescope with one foot raised above the level of the table, so that when the telescope was pointed to the Sun, the single motion of rotation about the pillar of the telescope (*i.e.* the motion for change of azimuth), would keep the Sun in the field of view, by making the telescope describe a tangent to the Sun's path. I found it necessary to tilt the pillar of the telescope through an angle of 15° for this purpose.

I considered that besides the convenience of having only one motion, there would be an advantage in referring my observations for polarization to known diameters other than the vertical and horizontal diameters.

The black line shows the position of the line of division of my crystal in the observations which I had planned. By moving my telescope in azimuth in one direction or the other, I passed into my second or third positions, passing through the highest point or the lowest point of the Moon's limb respectively.

The constants of my telescope are as follows:—

Aperture of object-glass	$2\frac{1}{4}$ inches.
Focal length	31 inches.
Diameter of field	About 50′.
Magnifying power	25.

so that the Moon's apparent diameter was about two-thirds of the diameter of the field. The Nicol's prism was so placed that for a beam of polarised light the two sides of the crystal were of the same pink tint in the centre when the index was at zero, the line of division of the crystal being then in the plane of polarization. On turning the eye-piece, the light on the right changes towards the more refrangible end of the spectrum, and the light on the left becomes red, then purple, and blue, until when it is turned through a right angle both sides at the centre are of the same uniform green tint. Turning from the first

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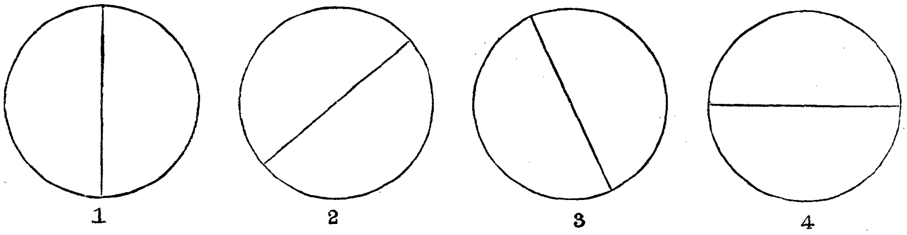
position in the opposite direction, the changes take place in the opposite direction.

With Prazmowski's arrangement, I had to bring the Sun into the centre of the field, and to observe first the tint on the two sides at the junction where the line of division of the two quartz plates cuts the limb, then to observe and note the changes of colour round the limb of the Moon on both sides. Then to pass to my second position, and to make the same series of observations, then to pass to my third position, and again observe for each point in the same way. If time remained, after these observations had been satisfactorily made,—as I had no one to assist me who could make the observations,—I should have used my delicate polarimeter, which was on its stand close to the telescope, and already directed on the Moon, to determine the plane and degree of polarization of the streamers. It was arranged that about two minutes before totality one of the Sappers should give the time at intervals of ten seconds, and that at the last minute before totality he should begin to count continuously and give every five seconds until after totality.



Large thick clouds were flying from the west, and frequently obscuring the Sun and rapidly passing away. When the Sun was about half eclipsed, there was rather a sudden change in the light and a sudden chill was felt in our observatory. About three minutes before totality there were brilliant and very remarkable patches of red and yellow light on a cloud to the right and rather below the Sun. This cloud passed away, and the Sun was quite clear. The time of totality was now very near, and a cloud from the west was threatening to blight our hopes; the band of sunlight was getting exceedingly thin and seemed to be breaking up into sections, when at the very instant the dense cloud came over the Moon and shut out the whole, so that it was doubtful whether the Moon or the clouds first eclipsed the Sun. For a full minute I could detect nothing of the Moon's disk, but moved my telescope very gradually, then the cloud became thinner, and I found the Moon still in the centre of the field. At the top and bottom I saw the dark limb, but no light outside it at these my first points of observation. To the north-east I saw light of the corona or prominences covering some 20° of the limb, and also a fainter light on the western limb of the Moon. I could not detect any colour or any difference of colour denoting polarization on the two plates of my bi-quartz. The Moon was

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again obscured entirely, but after a few seconds I again detected light of the corona near the point of emergence, and placed the line of division of my bi-quartz radial to the Moon, having the light in the centre of the field, but I could detect no trace of colour on the two parts of the crystal. The view then became continuous, and the totality was over.

I had found in my previous trials that for faint polarization the bi-quartz was not nearly so delicate as the quartz wedge or the Savart's bands, and these observations show that the polarization, either of the cloud or the corona, was so slight, that it was beyond the power of the bi-quartz crystal to detect it.

I had a very strong impression left on my mind that during totality, the light, which was of greater intensity than I had expected, was different from ordinary white light, and from many experiments I am strongly of opinion that bands rather than colour should be trusted to detect delicate polarization.

Mr. Clifford observed light polarized on the cloud to the right and left and over the Moon, in a horizontal plane through the Moon's centre, and found the plane of polarization inclined at from 15° to 20° to the vertical. At his last observation on the Moon, when it was visible, the plane of polarization was vertical.

Mr. Clifford also saw the corona near the point of emergence about the end of totality.

It will be seen from Mr. Clifford's observations that the plane of polarization by the cloud was very nearly parallel to the line of division of my crystal, *i.e.* nearly at right angles to the motion of the Sun.

Mr. Burton indicated the positions of some of the most remarkable prominences during the morning of the 22nd, and just before totality saw several lines in the spectrum (between D and E) in the chromosphere. At the beginning of totality, with his slit tangential and as near as possible to the east limb, a bright line was distinctly seen in the spectrum, very near E, and a little less refrangible. The line was less defined than the hydrogen lines of the prominences. On account of cloud, this was the only observation of the spectrum which Mr. Burton was able to make. No dark lines were seen. I examined the spectrum with the instrument after the eclipse was over, and found that with the width of the slit used the definition of the dark lines was exceedingly good. Mr. Burton had also intended to observe in order the west, north, and south points. Mr. Burton saw the corona on west side at the end of totality for about two seconds with the naked eye. He says, "The colour was *silvery white* fading *gradually* in brilliancy outward. I am not certain whether the outer boundary was definite or not, I incline to the latter opinion."